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(54) **A circuit for measuring energy transfer**

(57) In a circuit for measuring the transfer of energy, such as heat flow in a heating system, high frequency pulses from generator 17 are fed to a measuring device 18 for time periods whose frequency depends on the magnitude of a first parameter, e.g. fluid flow, and whose length depends on a second parameter, e.g. temperature drop. To avoid faulty measurements if the frequency of the generator 17 varies, the circuit provides means for modifying the length of the periods. The periods are started by a pulse from flowmeter 13 which opens a gate 22 between generator 17 and counter 18. The periods are terminated by a signal from a comparator 25 when a voltage applied to its first input and representing the number of pulses supplied to counter 18 during a period becomes equal to a signal representing the magnitude of the temperature drop. Thus if the frequency of the generator 17 drops the length of the periods increases accordingly and vice versa. In this embodiment, the comparison is effected in an analogue manner, but it may be effected digitally.

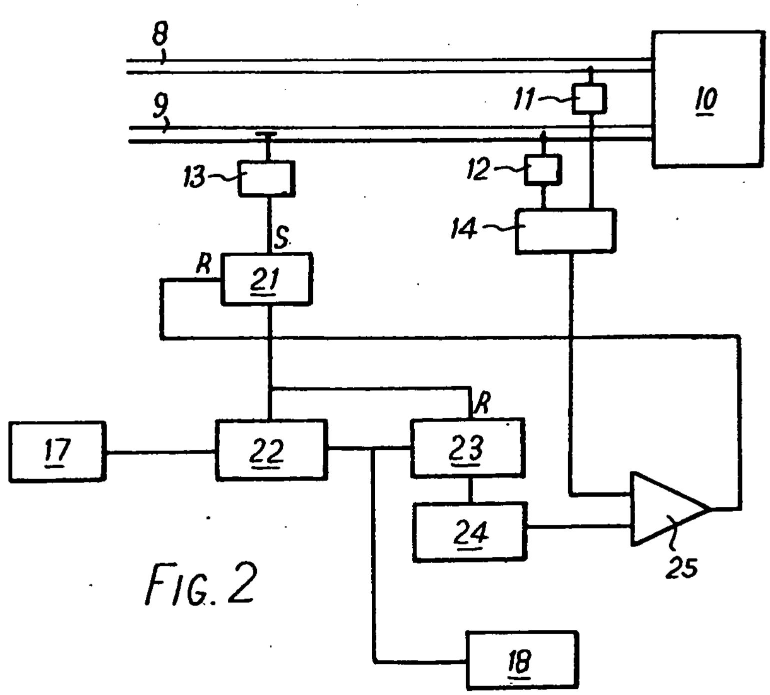

FIG. 2

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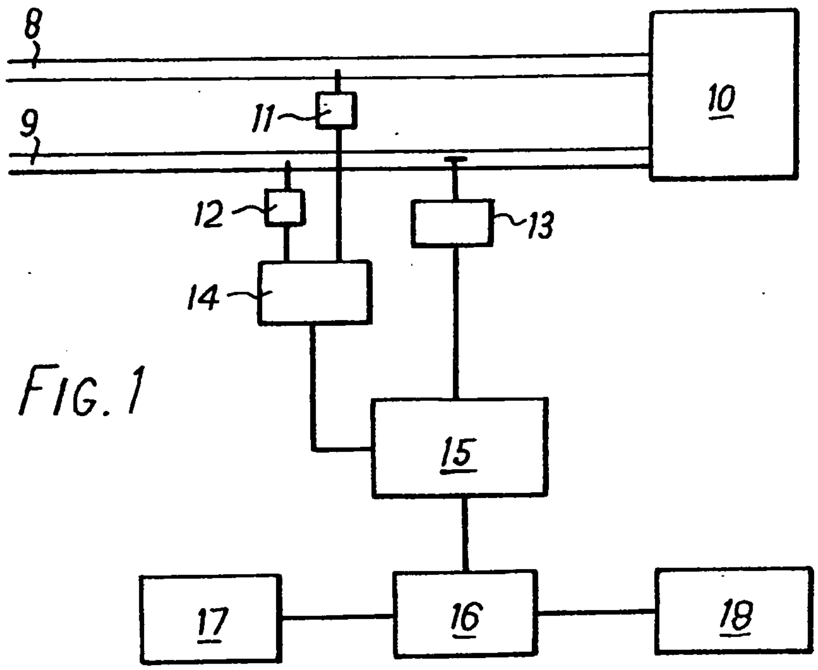

FIG. 1

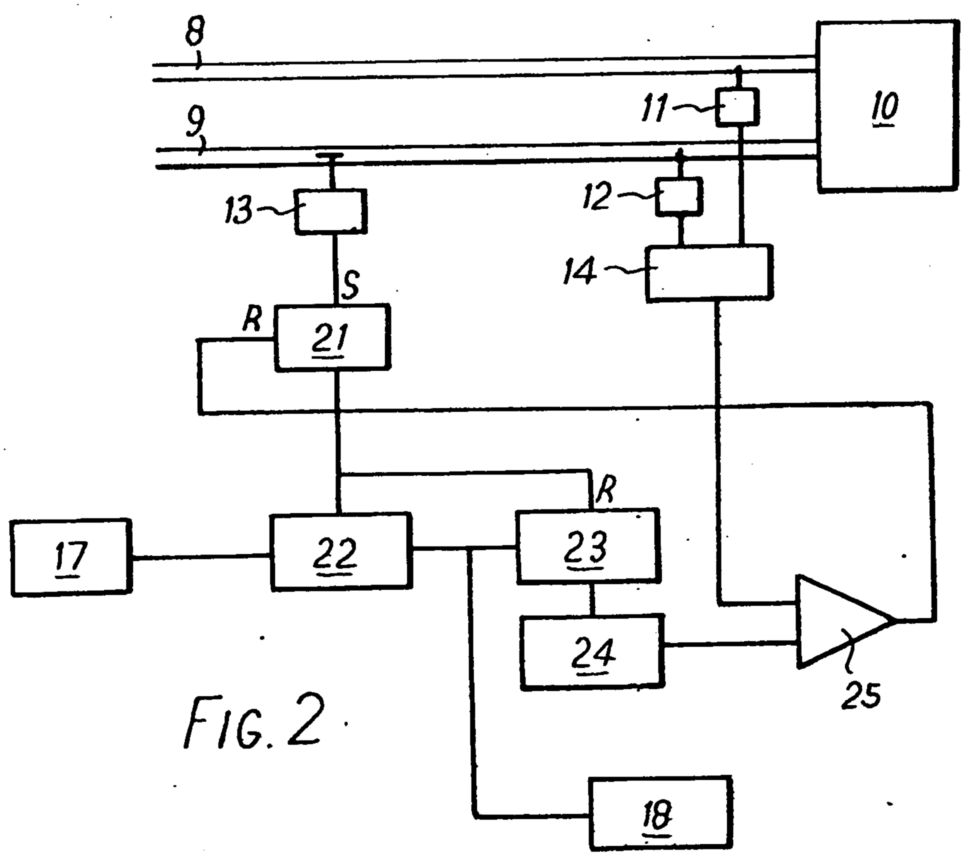

FIG. 2

SPECIFICATION

A circuit for measuring energy transfer

The present invention relates to a circuit for measuring the transfer of energy. In a preferred embodiment of the invention the heat transferred to or from a flowing fluid is measured.

In prior art circuits the energy transferred is measured by a device which is driven by a frequency source, the output of which is gated in accordance with the amount of energy being transferred. In many such circuits, if the frequency of the source changes over a period of time an inaccurate measurement of the energy transferred results.

One solution of the above problem has been proposed in German Offenlegungsschrift 28 16 611, which is concerned with determining the heat supplied by a flowing medium by measuring the temperature drop and rate of flow. Long term variations in the frequency of this source are catered for by having the frequency source coupled selectively to one or two counters. Each time a certain amount of medium has flowed, one of the counters is counted up to a predetermined count. During the counting period a capacitor is charged up by a current which is proportional to the temperature drop and to a supply voltage.

The frequency source is then coupled to the second counter which is counted up until the capacitor has discharged, the discharge current also being determined by said supply voltage. Providing the supply voltage and the frequency of the source do not change during a discharge cycle of the capacitor, the output of the second counter indicates the amount of heat supplied. However, should the supply voltage or the frequency of the source suffer from short term variations, an inaccurate result will be obtained.

It is an object of the present invention to provide an alternative solution to the problem of long term variations in the frequency of a source.

It is also an object of the present invention to provide a circuit wherein a correct result may be obtained despite short term variations of the frequency of the source, i.e. variations occurring while the source is supplying output pulses to a counter.

According to the present invention there is provided a circuit for measuring over a timespan the transfer of energy, the rate of transfer being manifested by variable phenomena, the circuit comprising means for detecting a first of said phenomena and producing a first electrical signal which varies as a function of that phenomenon, means for detecting a second of said phenoma and producing a second electrical signal which varies as a function of that phenomenon, a frequency generator which produces pulses which are intermittenly supplied for periods to the output of the circuit, means responsive to the first electrical signal for controlling the frequency of the periods, means responsive to the second electrical signal for controlling the length of the periods and for modifying the length of the periods in accordance with any change in the pulse frequency so that the total number of pulses received at the output of the circuit indicates the product of the values of the two phenomena integrated over time and substantially independent of such change in the pulse frequency said controlling and modifying means comprising counting means and comparing means, the counting means counting the pulses supplied to the output of the circuit during each period and producing a third electrical signal, the comparing means having as inputs the second and third electrical signals, and the output of the comparing means producing a fourth electrical signal for terminating said periods.

In a preferred arrangement the energy is heat transferred from a flowing medium to a heating system, the first phenomena being the rate of flow of the medium and the second phenomena being the temperature drop.

An embodiment of the present invention will now be described by way of example only with respect to the accompanying drawings of which:

Fig. 1 shows a prior art circuit for measuring energy transfer; and

Fig. 2 shows a circuit according to the present invention for measuring energy transfer.

Referring to Fig. 1. there is shown a known arrangement for measuring the amount of heat supplied to a heating system *via* feed and return pipes 8,9 which contain a flowing fluid, for example water. Sensors 11,12 measure the temperature of the feed and return fluid, and their outputs are fed to a comparator 14 to produce an electrical signal proportional to the temperature difference. A flow meter 13 generates electrical pulses at a rate which is proportional to the rate of fluid flow. The output of 13 indicates pulses from a modulated-width pulse generator 15, the width of the pulses being modulated by the temperature difference signal from comparator 14. The pulses produced by generator 15 are used to open a gate 16 which passes pulses produced by a frequency source 17 to an accumulating counter 18. The count accumulated by counter 18 is a linear function product of temperature difference and flow, that is heat energy transfer.

A disadvantage of the known arrangement described above is that the energy measurement depends on the frequency of source 17. Thus the arrangement requires a high stability frequency source.

Referring now to Fig. 2 there is shown a circuit in accordance with a preferred embodiment of the present invention. The output of flow meter 13 is supplied to the set input of a latch circuit 21. The output of latch circuit 21 is supplied to a gate 22 and the reset input of a counter 23. Gate 22 is connected between the clock input of counter 23 and frequency source 17, the frequency of which is substantially higher than that of the pulses from flow meter 13.

Gate 22 is also connected to the accumulating counter 18 which may be part of a heat meter incorporating an energy units display and/or a price display. The multiple outlets of counter 23 address a digital to analogue converter 24 the output of which is a staircase ramp and is fed to a first input of a comparator 25. The signal from comparator 14 representing the temperature difference is fed to the

record input of comparator 25. The output of comparator 25 is connected to the reset input of latch circuit 21.

In operation latch circuit 21 is set by each pulse from flow meter 13 so that gate 22 is opened and the reset is removed from counter 23. This allows the output of frequency source 17 to pass to the clock input of counter 23 and to the accumulating counter 18. An analogue representation of the count in counter 23 is obtained from D/A converter 24. When the output of converter 24 exceeds the temperature difference signal, comparator 25 resets latch 21 thus closing gate 22 and resetting counter 23. Thus actuation of counters 23 and 18 stops until the next pulse arrives from flow meter 13.

The output of the digital to analogue converter is $V_{DAC} = kfT$ to an accuracy of ± 1 step size, where k is a constant of proportionality

f is the frequency of the frequency source 17, and

T is the elapsed time from the opening of gate 22.

The temperature difference signal is $m\,\Delta t$ where m is a constant of proportionality and

Δt is the temperature difference.

The comparator 25 changes state when $V_{DAC} = m\,\Delta t$

i.e. $kfT = m\,\Delta t$

$$\text{i.e. } T = \frac{m\,\Delta t}{kf}$$

The number of pulses N allowed through gate 22 during time T is

$$\text{i.e. } N = \frac{m}{k}\ \Delta t$$

Thus an advantage of the above embodiment is that the number of pulses passed through gate 22 depends only on the temperature difference and the contents of proportionality and is independent of the frequency f. Thus drift of the frequency of source 17 with time and/or temperature is of no consequence.

With regard to the circuit of German Offlengungsschrift 28 16 611 there is the advantage that no source of constant supply voltage is necessary. Furthermore, with the circuit of the above embodiment, the number of pulses is independent of both long term and short term variations in the frequency of the source 17.

The above embodiment may be used in a heat meter for application in domestic systems supplied with hot water from a central source, for example in district heating schemes. In district heating schemes heat is supplied to users generally through hot water pipes, the water passing through a heat exchanger in the user's premises, whereby the user extracts the amount of heat he requires, returning the water at a reduced temperature. The energy abstracted depends on, and can be controlled by varying, the flow rate or the temperature drop or both. The user pays for the amount of heat extracted. Since flow rate and temperature may vary continuously throughout a given period the heat meter monitors both factors on a substantially continuous basis and relates them to produce a running total for the energy extracted from the thermal source. The heat meter may be alternatively used in chemical plant, food manufacture or conventional central heating system.

With the above embodiment, when it is desired to increase the tariff charged for heat used, it is a relatively simple matter to adjust one or both of the constants of proportionality *k* and *m* as required. Counter 18 will then count correspondingly faster.

Various modifications of the above described embodiment may be made within the scope of the invention. For example gate 22 may be omitted and the output of latch circuit 21 supplied directly to an inhibit input of frequency source 17.

The comparison of the outputs of counter 23 and comparator 14 may be effected digitally. In this case D/A converter 24 is omitted, and an A/D converter (not shown) is connected to the output of comparator 14. Counter 23 may also be omitted. An up-down counter replaces comparator 25. The output of the A/D converter is sampled before flow meter 13 emits a pulse and the up-down counter is counted up to this value. The output of frequency source 17 is then used to count down the up-down counter. Latch circuit 21 is reset when the up-down counter reaches zero.

The inputs to the energy measuring circuit may be modified so that they produce pulses with a rate proportional to the temperature difference and a voltage proportional to flow rate.

The circuit of the present invention may be used with supply systems for energy other than heat. For example in a hydraulic energy supply system pressure drop and flow could be used as inputs. Alternatively in an electrical supply system with a fluctuating voltage, the voltage and current used could serve as inputs to the energy measuring circuit.

The present invention may also be used to measure the energy transferred from a source, for example a central heating boiler.

CLAIMS

1. A circuit for measuring over a timespan the transfer of energy, the rate of transfer being manifested by variable phenomena, the circuit comprising means for detecting a first of said phenomena and producing a first electrical signal which varies as a function of that phenomenon, means for detecting a second of said phenomena and producing a second electrical signal which varies as a function of that phenomenon, a frequency generator which produces pulses which are intermittently supplied for periods to the output of the circuit, means responsive to the first electrical signal for controlling the frequency of the periods, means responsive to the second electrical signal for controlling the length of the periods and for modifying the length of the periods in accordance with any change in the pulse frequency so that the total number of pulses received at the output of the circuit indicates the product of the values of the two phenomena integrated over time and substantially independent of such change in the pulse frequency, said controlling and modifying means comprising comparison means which has a first input an electrical signal representing the number of pulses supplied to the output of the circuit during each period and as a

second input the second electrical signal, the comparison means having an output which produces an electrical signal for terminating each period.

2. A circuit according to claim 1, wherein the first electrical signal is in the form of a second train of pulses the frequency of which is substantially lower than that of the first mentioned pulses, and the means responsive to the first electrical signal is constituted by gate means for selectively permitting or inhibiting the passage of the first mentioned pulses from the frequency generator to the output of the circuit.

3. A circuit according to claim 2, wherein the gate means is constituted by a latch circuit the output of which is connected to selectively open or close a gate circuit connected between the frequency generator and the output of the circuit.

4. A circuit according to claim 2 or 3, wherein the electrical output signal of the comparison means is coupled to the gate means, and terminates each period by inhibiting the passage of the first mentioned pulses.

5. A circuit according to any preceding claim wherein the second electrical signal is in the form of an analogue voltage, and wherein the first mentioned pulses supplied to the output of the circuit are also supplied to counter means, the output of the counter means being connected *via* a D/A converter to the first input of the comparison means.

6. A circuit according to claim 5, wherein the ratio between the magnitude of the second electrical signal and the magnitutude of the second phenomenon is adjustable.

7. A circuit according to claim 5, or 6, wherein the ratio between the magnitude of the output of the D/A converter and the frequency of the input thereto is adjustable.

8. A circuit according to any of claim 5 to 7, wherein the electrical output signal of the comparison means which terminates each period also resets the counter means.

9. A circuit according to any of claims 1 to 4, wherein the second electrical signal is in digital form and the comparison means is constituted by an up-down counter, the second electrical signal being arranged to count the up-down counter up to a certain value, and the first mentioned pulses which are supplied to the output of the circuit also being arranged to count down the up-down counter.

10. A circuit according to any preceding claim wherein a measuring device is connected to the output of the circuit.

11. A circuit according to claim 8 wherein the measuring device includes indicating means.

12. A circuit according to any preceding claim wherein the energy is heat transferred from a flowing medium to a heating system, the first phenomenon being the rate of flow of the medium and the second phenomenon being the temperature drop.

13. A circuit substantially as herein described with reference to Figure 2 of the accompanying drawings.

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